

EOS-Aqua (PM) Instrument Status

**Moderate Resolution Imager Spectroradiometer (MODIS)
Flight Model One (FM1)**

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Santa Barbara Remote Sensing (SBRs)
Goleta, CA**

Agenda



- List of recent activities
- Performance Status
- Conclusions/Summary

FM1 Recent Activities



- Completion of TV3 in August '99
- Diagnostics performed August'99 thru October '99
- Instrument has completed pre-ship Bench Acceptance Test (BAT)
- Currently awaiting shipment to TRW 11/17/99

MODIS Flight Model 1 (FM1) Performance Status Summary



- **Initial objectives of TV3**
 - **Verify fixes of problems discovered in TV2 (Oct-Nov '98)**
 - Power supply shutdown
 - Door fail-safe operations
 - Focal plane telemetry instability
 - **Verification of radiometric calibration baseline established in TV2**
- **All initial objectives accomplished**
 - Adequate power supply load handling capability verified
 - Door fail-safe operations successfully completed
 - Focal plane telemetry stability confirmed
 - Excellent agreement with TV2 radiometric calibration baseline verified
 - NEdTs/Calibration Coefficients

MODIS Flight Model 1 (FM1) Performance Status Summary



- **Issues surfaced during TV3**
 - Correlated Noise Sources (also observed on PFM)
 - Spatial pointing and registration changes
 - Analog -to- digital converter bin size anomalies
 - Gain change of Bands 23 and 32
- **SMWIR operability problems discovered post-TV3**



- **Unexpected sector to sector and scan to scan offsets observed on the PFM and FM1**
 - Suspect power supply switching noise coupling into sensitive circuits
 - Magnitude of noise influenced by power supply load
- **OBC blackbody heater on/off power cycle time changed for PFM and FM1**
 - Limiting the heater “on” time in a given scan reduces correlated noise observations in the science DNs
 - Two operational modes now provided (30% or 100% of scan)
 - Significant reduction in offset noise achieved with 30% blackbody operational mode
 - OBC BB achieves a 290K steady state temp at 30% cycling (with instrument at nominal temperature plateau)
- **Use of SMWIR FPA temp control (vs LWIR FPA temp) also provides more immunity to noise**
 - Due to larger thermal time constant to the LWIR FPA

FM1 Spatial Registration and Pointing Shift



- One-time shift observed in TV3
 - Approximately 20-30% in scan/track
- TV3 and Post-TV3 diagnostics showed stability based on
 - 2 diagnostic radiative cooler cycles during TV3
 - 2 Instrument temperature cycles (-16C to 22C) during TV3
 - Multiple 1-g orientation tests conducted post-TV3
- Raytheon internal peer and science/GSFC reviews held during August/September
- Suspect “Resetting” of a mechanical/structural interface
 - Testing/stability supports theory of a one-time event
 - Plan to use-as-is and monitor during S/C integration
- Limited S/W correction available in scan direction

A/D Converter Differential Non-Linearity Performance



■ Background history

- 12-bit “quantizer system” (4095 DNs) has a Min/Max requirement of +/- 0.5 DN differential non-linearity
- Each DN equally weighted (individual DN-frequency compared to average frequency of all DNs)
- Applies to all DNs within radiometric calibration range (~200 to 3800 DN)
- MODIS marginally exceeded the min/max spec
 - Only a few codes failed min/max requirement
 - 2-sigma performance (<0.5DN) accepted by NASA via RDW

A/D Converter Differential Non-Linearity Performance



- Recent data (TV3) showed performance variability on Bands 31 thru 36
 - 2-sigma differential non-linearity (DN frequency statistics) measured up to 2 DN
 - Caused by A/D converter bin size instability due to system noise
 - * Based on engineering model testing results
 - * Noise introduced by power supply and timing electronics switching
 - * A/D convert pulse “window” is coincident with system timing
 - Performance is also instrument configuration dependant
 - Behavior seen on electronics side “A”
 - Behavior not seen on electronics side “B”

A/D Converter Differential Non-Linearity Performance



■ Side “A” impact

- Bin size variations could introduce a differential non-linearity variation of up to 2 DN (2-Sigma) on bands 31 through 36
- Worst case differential non-linearity should be compared to the noise quantization (NEdT) profile
 - Typical MODIS measured noise distributions used in NEdT calculations
 - * Bands 33 - 36: Approx. 30 DN pk-pk
 - * Bands 31 - 32: Approx. 3 DN pk-pk (current NEdT margin will keep the performance within the requirement)
- A/D contribution to overall radiometric accuracy can be quantified by evaluating the “integral” non-linearity
 - SBRS predicts up to 2 DN worst case integral non-linearity
 - A 2DN integral non-linearity at L_{typ} (1000dns) for B31/B32 results in a 0.2% uncertainty in overall accuracy at L_{typ}
- All affected bands (31 thru 36) meet accuracy requirements
 - Specifically, B31/B32 meet a 0.5% SST accuracy requirement
 - B31/B32 degrade to 0.33% with the A/D effect, from 0.26% without the A/D effect (Goal was 0.25%)



- **TV3 comparable to TV2 in calibration coefficients**
 - Radiometric differences are 1st order
- **Two bands exhibit larger 1st order changes than others (B32/B23)**
 - Appears to occur only in TV3; not seen in ambient
 - Will trend at the S/C level
 - Analysis shows small beam vignette as possible cause
 - Stable over TV3
 - No IFOV size impact observed



- Review of TV3 data uncovered non-responsive detectors on band 6, and 1 non-responsive detector on band 5
- Of 20 channels on Band 6, during TV3
 - 6 are inoperable at 83K (channels 1,2,5,7,8,19)
 - 2 additional channels are inoperable at 88K (channels 4,9)
 - 3 additional channels are inoperable between 88K and 118K (11,16,17)
- Not present in TV2 test
- No direct method of analyzing effects other than in TV
 - Bands do not operate in ambient/bench test cooled environment
 - Band evaluation occurs only in a radiatively-cooled environment
- Indirect method developed recently (DC restore offsets/ECAL ramps) allows for operability assessment in ambient environment



- **PFM –vs- FM1 –vs- FM2 design, manufacturing, testing review**
 - Materials, processes, tests, test configurations, fabrication history/performance, yields, major events during fabrication and test cycle, personnel changes, equipment/facilities changes, etc
 - SWMIR FPA –vs- other Modis FPAs comparison
 - Susceptibility to failure mode
- **Process and production history review**
 - Other customers, performance history (before/after Modis), process maturity
- **Modis life/qualification test program review**
 - Sample/population size, tests performed/results, further test requirements/needs
- **Models/simulations**
 - Structural, thermal predictions, reliability analysis
- **FM2 FPA reliability/performance/operability assessment**
 - Available data
 - Additional testing

FM1 SMWIR B5/B6 Operability Results to Date



- **Anomaly most likely caused by deficiency of Indium bump interface**
 - **Between the detector and readout chip**
 - Electrical tests have supported this conclusion
 - **Manifestation of deficiency accelerated by thermal cycling**
 - FM1 test history review shows onset at about thermal cycle #70 (vs a 150 cycle spec/expectation)
 - **Some evidence of stress relief is apparent**
 - Phenomenon has been stable for 15+ thermal cycles
 - **Exact cause would require a complete disassembly/destructive diagnostic on the FPA**
 - Studies must consider a number of possible causes, along with associated reliability predictions
 - **To date, failure investigation results do not imply catastrophic consequences for the FPA**
 - **Results from planned analyses may give a more quantitative risk assessment**
- **Effort being coordinated with NASA GSFC**
 - **Impact to mission objectives**
 - **Long term stability of operational channels**

FM1 Status Summary



- **FM1 SBRs test program complete**
 - Calibration (RVS/Spectrals/NEdT/Coefficients/Accuracy) continues to show in-spec performance
 - Anomalies/associated reliability questions will remain
 - Spatial, B31-36 ADCs, B32/B23 Response Stability, SMWIR Operability
- **Baseline acceptance test (BAT) at SBRs completed**
- **Spacecraft Instrument Interface Simulation (SIIS) test completed**
- **Shipment to TRW planned for 11/17/99**
- **SBRs will continue investigations**
 - Need to take advantage of S/C level tests to acquire MODIS data when appropriate
 - Modeling/related test activities are proceeding